# TRABAJOS DE INVESTIGACION

# COMPOSITION AND POTENTIAL USE OF SOME TROPICAL FRUITS[1]

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## SUMMARY

**The nutritional role fruits could play in poor-quality diets, as sources of vitamin A and ascorbic acid, is described. Likewise, summarized information is presented on the use of some unknown tropical fruits relatively abundant in Central America as components of high-protein foods, providing nutrients such as provitamin A and ascorbic acid, as well as a variety of flavors. In these studies the fruit pulp as a purée was added either fresh or drum-dried, to a corn-soybean blend. In all cases there occurred a decrease in protein quality, which was more marked for some fruits than for others, probably due to the dehydration process used. The chemical composition of other tropical fruits, not consumed by people but which could be used as animal feed, is also presented. This type of fruits includes the Chalum (Inga, spp.) and some Cucurbitaceae. Others contain seeds with a high oil and protein content. Among the latter, Jícara (Crescentia alata) offers very good industrial possibilities.**

## INTRODUCTION

Latin America has a large number of tropical fruits with interesting characteristics of flavor and nutrient content, particularly

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vitamins which, if properly studied, could make significant economic, industrial and nutritional contributions to both men and animals. In general, these fruits are very little known, either because attention has been given only to the more traditional ones, or because national agricultural agencies do not include in their programs research oriented to exploit these natural resources.

In Central America, however, some research is being carried out mainly by national institutions responsible for food science and technology programs which follow traditional lines, such as increasing storage time by cold temperature or waxing (1), chemical and physiological studies related to storage and transportation (2, 3), chemical characterization during maturation (4, 5), preparation of fruit juices and concentrates (1), dehydration studies (6), and development of fruit-derived products such as jams, marmalades and the like ( 1,7, 8 ). As indicated above, these studies are being carried out with common fruits, but not with the less known fruits.

Consideration has been given to the role that some fruits could play in improving the nutrition of the area. For example, studies have been performed on the nutritional contribution of the Na, K,and vitamin content in fruit juices (9).

In the present paper we will discuss other possibilities for using such fruits as sources of nutrients which have been shown to be deficient in the diet of many population groups in Latin America. It has been demonstrated that aside from the calorie-protein deficiency, these populations also suffer from deficiencies of other nutrients, among which vitamin A and riboflavin are important. Similarly, in a variety of occasions it has been found that vitamin C deficiency also occurs. Futhermore, we shall comment the role that the pulp and seeds of some fruits could play as protein and oil sources and, sometimes, as animal feeds, using either the whole fruit or its by-products.

## TROPICAL FRUITS AS SOURCES OF CAROTENE, VITAMIN C AND ENERGY

The INCAP-ICNND Food Composition Table for Use in Latin America (10) lists the chemical composition of around 180 fruits, including products derived from them. Fruits with a high concentration of carotene and of ascorbic acid were selected from the above-mentioned lists, as examples of potential or actual sources of these nutrients in the diet (Table 1). As the data reveal, for vitamin A activity values range from 110 to 835 mcg %, while their ascorbic acid content fluctuates between 6 and 79 mg %. Hawthorn (a variety of crab apple) is particularly high in vitamin A activity as well as peach, palm fruit, and pitanga. Hawthorn is al-

TABLE 1

SOME TROPICAL FRUITS OF INTEREST FOR THEIR HIGH CAROTENE AND ASCORBIC ACID CONTENT (WET BASIS)

| Name of the fruit | | | Vitamin A activity, mcg % | Ascorbic acid, mg % |
|---|---|---|---|---|
| English | Spanish | Scientific | | |
| Mango | Mango | *Mangifera indica* | 630 | 53 |
| Hawthorn | Manzanilla | *Crataegus pubeacens* | 835 | 79 |
| Muskmelon | Melón | *Cucumis melo* | 350 | 29 |
| Persimmon | Palo Santo | *Diospyros kaki* | 750 | 11 |
| Papaya | Papaya | *Carica papaya* | 110 | 46 |
| Peachpalm fruit | Pejibaye | *Guilielma gasipaes* | 670 | 36 |
| Pitanga | Pitanga | *Eugenia uniflora* | 635 | 14 |
| Plantain | Plátano | *Musa paradisiaca* | 175 | 20 |
| Soncoya | Sincuya | *Annona purpurea* | 360 | 28 |
| Uchi | Uchi | *Endopleura uchi* | 165 | 6 |

TABLE 2

SOME TROPICAL FRUITS OF INTEREST FOR THEIR HIGH OIL CONTENT

| Use | Name of the fruit | | | Water g/100 g | Fat |
|---|---|---|---|---|---|
| | English | Spanish | Scientific | | |
| F | Avocado | Aguacate | *P. americana* | 77.0 | 15.8 |
| F | Enterpepalm | Acai | *E. oleracea* | 41.0 | 12.2 |
| F, I | Coconut | Coco | *C. mucifera* | 54.6 | 27.2 |
| F, I | Cacao | Cacao | *Teobroma cacao* | 3.6 | 46.3 |
| F, I | *Calabash tree* | Morro | *Crescentia alata* | 3.4 | 39.7 |
| F, I | Peachpalm fruit | Pejibaye | *Guilielma gasipaes* | 40.0 | 16.8 |
| F, I | Pumpkin seed | Pepitoria | *C. pepo* | 4.9 | 45.8 |
| I | Coyol fruit | Coyol | *A. mexicana* | 51.8 | 13.8 |
| I | African oil palm | Palma de aceite | *E. guineensis* | 28.0 | 59.0 |

F = Food.

I = Industrial uses.

so relatively rich in ascorbic acid, although its value is not as high as that of the well-known Barbados cherry or acerola.

Calorie deficiency is also of importance in many developing countries of the tropics. Table 2 shows that it would be possible to increase the energy intake in human populations if such fruits or their components were consumed regularly. As the Table indicates, fat content varies in this group of fruits from 16.8 to 59.0%. Two of these, the seeds of the calabash tree and of the pumpkin, are consumed as flours suspended in water or as a component of native sweets and candies. The oil of these two seeds can be easily extracted following the usual techniques, leaving a residue with a high-protein content. The respective oils are of good edible quality and highly digestible (11, 12).

## UTILIZATION IN HIGH-QUALITY PROTEIN FOODS

Fruits are not usually the cheapest kind of food in the human diet; however, due to the abundance of some of them, to the large losses resulting from inadequate preservation, and to poor or limited markets and little industrialization, some attention has been given to the possibility of using them in the preparation of high-protein foods. Up to this moment we have used the two formulations presented in Table 3. Formulation A has been prepared with up to 30% fruit solids, while Formulation B contains only 20%. The protein and oil from these mixtures are supplied mainly by soybeans, although corn or any other cereal grain also provide some protein.

TABLE 3

MIXTURES OF MAISOY* WITH FRUIT SOLIDS (DRY BASIS)

| Mixtures | Formulation | |
|---|---|---|
| | A | B |
| Soybean** | 30 | 45 |
| Whole corn | 40 | 35 |
| Fruit solids | 30 | 20 |
| Total | 100 | 100 |

* Bressani, Murillo and Elías (13).

** Dehulled.

These blends have been prepared following the scheme shown in Figure 1. The fruit is processed as a purée and then mixed, in the appropriate amount, with soybeans and corn. The blend is then passed through a double-drum dryer, at a speed of 3-4 rpm using 60 psi steam pressure in the drums. The product thus obtained is ground to a flour.

As illustrated in Figure 2, other products have also been pre-

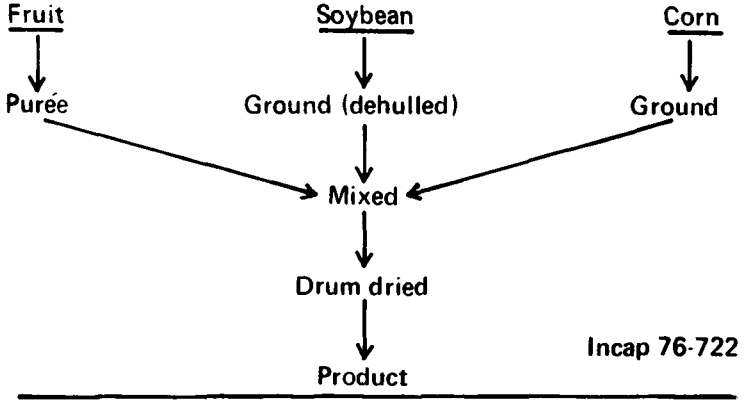



Fig. 1 Method used to incorporate fruit purée into a basic soybean/corn blend to make a dry food.

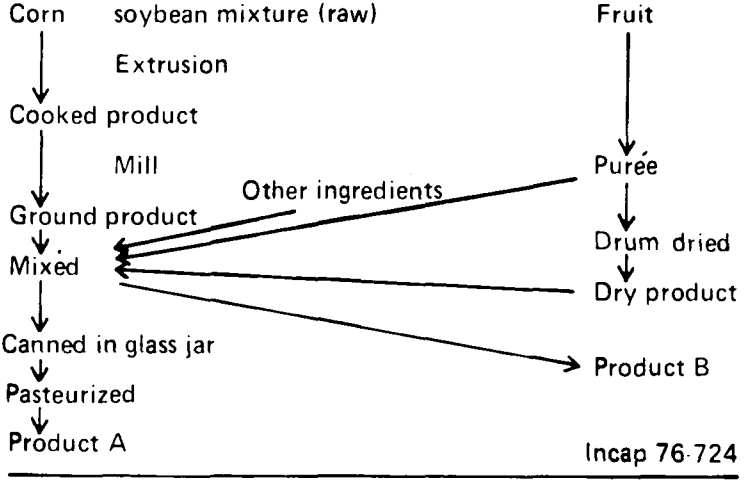



Fig. 2 Method used to incorporate fruit purée into a basic soybean/corn blend

pared. In this case, the fruit purée is either drum-dried or blended with a corn-soybean mixture (13) processed by extrusion cooking so as to obtain a soft paste or a dry powder. The chemical composition of some of the preparations studied is shown in Table 4. As may be observed, Group A products contained 30% fruit solids, while Group B products were prepared with 20% fruit solids. The protein content in Group A ranged from 13 to 16% while fat content fluctuated from approximately 7 to 10%. On the other hand, those fruits in Group B contained more protein (around 20%) and more fat (approximately 10%). These differences are due to a higher soybean content and a lower concentration of fruit solids in the Group B products.

All these preparations have been subjected to biological assay for protein quality using either the protein efficiency ratio method or a protein repletion technique. For this purpose, rats of the Wistar strain from the INCAP animal colony were used. The fruit purée was added as a source of vitamin A or C or as a flavor or color component. Nevertheless, the biological tests were done for protein quality having obtained the representative results given in Table 5. Those for the fruit purées used are shown in the first column, and the third and fourth columns indicate the protein and fat content of the formulations. For the assay, the protein in the mixture was diluted to 9%, and the experiment was run for 28 days. Average weight gain for all rat groups fed preparations containing fruit solids was lower than that of the control group. The guava and hawthorn blends, however, were superior to those prepared with plantain or bananas. All mixtures showed a lower protein quality than casein. Table 6 shows the biological results obtained with other preparations when using a protein repletion technique. In this case, 5-week-old rats were fed a protein-free diet for 15 days to induce protein depletion. They were then fed with blends adjusted to 9% protein in the diet for 10 days. The results obtained followed the same tendency as those given in Table 5. The blends containing fruit solids resulted in a poorer performance than that of the control group, although all were capable of inducing protein repletion. These results have been interpreted to mean that either the fruit solids reduce the total sulfur amino acid content of the soybean/corn mixture, or that drum drying induces a decrease in available lysine, by favoring lysine-sugar reactions. These possibilities are now under study.

The blends tested biologically have been subjected also to stability trials under storage using different temperatures and different packaging materials. Table 7 illustrates some of the pertinent findings. They indicate that the vitamin C content decreases with storage time, and that this decrease is greater as the storage temperature increases. The packaging material has no apparent effect

TABLE 4

CHEMICAL COMPOSITION OF HIGH-PROTEIN FRUIT FORMULAS

| | Water g % | Protein (N x 6.25) g % | Fat g % | Fiber g % |
|---|---|---|---|---|
| **Group A (30% fruit solids)** | | | | |
| Maisoy*/Plantain | 4.9 | 12.8 | 7.5 | 1.9 |
| Maisoy/Guava | 5.5 | 13.9 | 8.6 | 9.0 |
| Maisoy/Banana | 3.8 | 16.1 | 8.9 | 2.4 |
| Maisoy/Hawthorn | 4.9 | 16.2 | 9.6 | 3.8 |
| **Group B (20% fruit solids)**** | | | | |
| Maisoy/Plantain | 3.6 | 19.7 | 10.8 | |
| Maisoy/Whitesapote | 4.6 | 21.1 | 9.7 | |
| Maisoy/Mango | 3.0 | 20.7 | 10.3 | |
| Maisoy/Hawthorn | 5.0 | 20.0 | 11.0 | |

* Bressani, Murillo and Elías (13).

** Crude fiber not determined.

TABLE 5

CHEMICAL QUALITY OF A HIGH–PROTEIN FOOD CONTAINING DEHYDRATED FRUIT PUREE*

| Fruit | Source | Protein % | Fat % | Average wt gain, g | PER |
|---|---|---|---|---|---|
| None | | 18.0 | 10.3 | 98 | 2.22 |
| Plantain | Vitamin A | 14.9 | 7.5 | 56 | 1.33 |
| Guava | Vitamin C | 15.6 | 8.6 | 78 | 1.56 |
| Banana | Flavor | 18.1 | 8.9 | 33 | 0.88 |
| Hawthorn | Vitamin A | 18.1 | 9.6 | 77 | 1.57 |
| Casein | | - | - | 153 | 3.09 |

* Diets were calculated to contain 9% protein.

TABLE 6

PROTEIN QUALITY OF HIGH-PROTEIN FOOD MIXTURES WITH FRUIT SOLIDS, AS EVALUATED IN RATS BY THE PROTEIN DEPLETION-REPLETION METHOD

| | Average wt gain (10 days) g | Food intake g/10 days | Relative nutritive value |
|---|---|---|---|
| Maisoy*/Banana | 86 | 96 | 43.4 |
| Maisoy/Hawthorn | 101 | 121 | 63.6 |
| Maisoy/Mango | 96 | 113 | 57.4 |
| Maisoy/Plantain | 82 | 91 | 31.5 |
| Maisoy/Whitesapote | 76 | 77 | 19.9 |
| Maisoy/Starch | 110 | 127 | 80.6 |
| Casein | 126 | 146 | 100.00 |

*Bressani, Murillo and Elías (13).
Initial weight: 70 g/rat.

in reducing losses of this nutrient. The storage tests also included determination of free fatty acid content and of organoleptic characteristics, which indicated deterioration as storage time and temperature increased.

Other preparations have been studied also. One of particular interest is a popular drink in Brazil made from avocado's pulp, cow's milk and sugar; it has a green color and the consistency of malted milk. Other beverages have been prepared using soybean and avocado pulp in formulations as that shown in Table 8 which consists of 200 g soybean milk, 100 g avocado pulp, and 60 g sugar. A 120 g portion of this drink provides around 142 cal, 3 g of protein and 4 g of fat. The preparation method is described in Figure 3. Whole soybeans are processed to obtain whole soybean milk, and this is blended with avocado paste, flavoring and sugar; if the soybean milk is properly made, its taste can be very pleasant. The problem at the present time is the difficulty to dehydrate this product without altering its appearance and organoleptic quality, alteration which is caused by the poor stability of avocado paste.

## UTILIZATION OF FRUITS AS ANIMAL FEED

There are in Latin America other fruits which are not largely consumed by the people, but because of their relative abundance, we have become interested in their utilization. An example in this

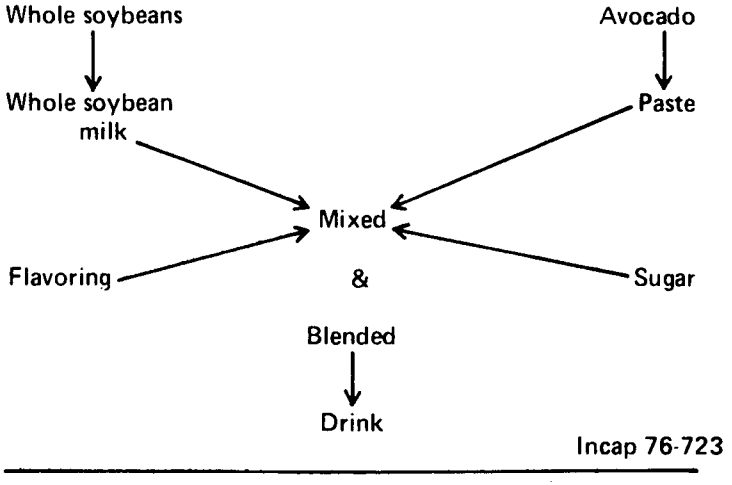



Fig. 3. Preparation of a high-protein food with soybean and avocado.

TABLE 7

ASCORBIC ACID RETENTION DURING PROCESSING AND STORAGE (3 MONTHS) OF MAISOY*/FRUIT

| Mixture | | Calculated value | Initial | 5°C | 25°C | 32°C |
|---|---|---|---|---|---|---|
| | | | | mg/100 g | | |
| Maisoy/Guava | 1 | 340 | 386 | 316 | 321 | 271 |
| | 2 | | | 335 | 397 | 225 |
| Maisoy/Hawthorn | 1 | 66 | 40 | 95 | 44 | 19 |
| | 2 | | | 41 | 32 | 25 |
| Maisoy/Banana | 1 | 3 | 4 | 2 | 2 | 2 |
| | 2 | | | 2 | 3 | 3 |
| Maisoy/Plantain | 1 | 6 | 9 | 7 | 7 | 3 |
| | 2 | | | 6 | 6 | 2 |

* Bressani, Murillo and Elías (13).
1 = Paper bag with plastic lining.
2 = Plastic bag.

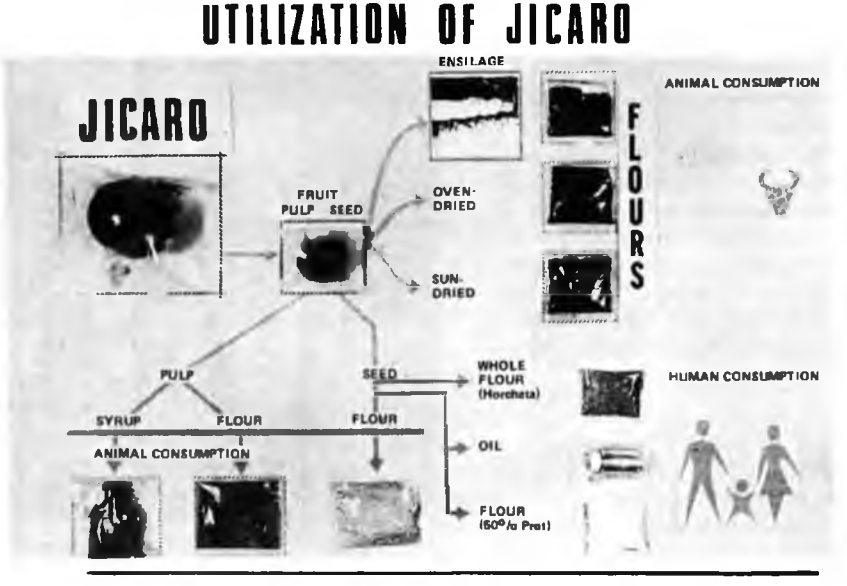
TABLE 8

HIGH-PROTEIN ENERGY FOOD MADE FROM SOYBEANS AND AVOCADO PULP

| Ingredient | g |
|---|---|
| Soybean milk | 200 |
| Avocado pulp | 100 |
| Sugar | 60 |

**120 g of portion provide 142 cal, 3 g protein and 4 g fat.**

regard is shown in Figure 4 for the Jícara or Morro (**Crescentia alata**) (11, 14). The research carried out and the products obtained are shown schematically in the above-mentioned Figure. The fruit, as large as a small coconut, has a hard cover which holds a very aromatic pulp, and the seeds. The whole fruit or the pulp can be dried to produce a flour or other products which have been used as animal feed. The seeds, high in protein and oil content can be




Utilization of Jícaro.

TABLE 9

CHEMICAL COMPOSITION OF MORRO *(Crescentia alata)* AND OF SOME OF ITS PREPARATIONS (%)

| | Moisture | Ether extract | Crude fiber | Protein | Ash | CHO |
|---|---|---|---|---|---|---|
| Fruit without coat | 68.5 | 5.3 | 3.6 | 6.2 | 2.0 | 14.7 |
| Whole fruit flour: | 6.2 | 17.8 | 11.6 | 18.9 | 6.4 | 39.1 |
| pulp | 72.0 | 1.2 | 2.6 | 3.3 | 2.2 | 18.7 |
| dried seeds | 7.8 | 33.4 | 16.8 | 25.1 | 3.2 | 13.7 |
| Flour, human-grade | 11.7 | 0.9 | 8.8 | 53.6 | 8.1 | 16.9 |
| Flour, feed-grade | 11.6 | 0.7 | 21.9 | 39.7 | 6.5 | 19.6 |

ground and consumed as a water suspension or emulsion, or they can be oil-extracted, yielding a protein-rich flour. Both the oil and the protein are of relatively high nutritional value. The chemical composition of the fruit and of its components as well as of some products made from them, are shown in Table 9. As the data reveal, the dehydrated pulp is relatively high in its protein and fat content and it has been tested biologically as source of these nutrients in animal feeding, with acceptable results. The tests were conducted reducing the cereal grain in the diets. The dried seeds are also rich in protein and oil and, as indicated before, they are being utilized as component of high-protein foods for human feeding. Another example, that of the Chalum (**Inga** Spp.) is shown in Table 10. This fruit, from a leguminous tree very often found in coffee plantations, contains around 12.5% crude protein and 27.2% fiber, composition which is similar to that of many forages. The fruit, weighing around 60 g, is made up of pods and seeds, which represent 50-55% and 44% of the total weight, respectively. The whole fruit or the seeds can be used as a feed ingredient for swine, dairy or beef cattle, while the pods can be fed to ruminants.

To our knowledge, feeding tests have not been carried out as yet, but preliminary acceptability tests in swine suggest the fruit to be acceptable and nontoxic. It should be indicated here that the idea is to use these products to replace cereal grains in animal diets, for even if only small amounts were replaced, this would to some extent increase availability of cereal grain for human consumption.

Another fruit with much potential is the chilacayote, a cucurbitaceae, which is planted in corn fields by the natives as a source

**TABLE 10**

**CHEMICAL COMPOSITION OF DEHYDRATED CHALUM *(Inga Spp)* FRUIT AND SEEDS (g/100 g)**

| | Fruit | Pods | Seeds |
|---|---|---|---|
| Dry matter | 96.8 | 97.8 | 93.5 |
| Ether extract | 1.2 | 1.5 | 1.0 |
| Crude fiber | 27.2 | 36.9 | 3.6 |
| Protein | 12.5 | 9.8 | 20.2 |
| Ash | 3.1 | 4.4 | 2.0 |
| Weight distribution (%) | 100% (61 g) | 55.7% | 44.3% |

of food. The seeds can be used in swine feeding. Its chemical composition (Table 11), reveals that the fruit contains around 8% crude protein and 16% fiber on a dry-weight basis. As some of the other fruits mentioned previously, the seeds are high in oil and protein content.

TABLE 11

CHEMICAL COMPOSITION OF DEHYDRATED CHILACAYOTE *(Malabargourd) (Cucurbita ficifolia)* (g/100 g)

| | Whole fruit | Seeds* |
|---|---|---|
| Dry matter | 92.3 | 98.0 |
| Ether extract | 5.6 | 37.6 |
| Crude fiber | 15.7 | 17.1 |
| Protein | 7.8 | 31.8 |
| Ash | 6.0 | 5.2 |

* Dry weight basis.

Attention has also been given to the caulote fruit, which according to its chemical composition shown in Table 12, has around 10% protein and 22% crude fiber. It is highly acceptable by cattle since it is sweet, although its tannin content is very high.

TABLE 12

CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF CAULOTE *(Guazuma ulmifolia,* Lam)*

| | % |
|---|---|
| Dry matter | 93.3 |
| Protein | 10.0 |
| Crude fat | 4.7 |
| Crude fiber | 22.3 |
| Ash | 3.1 |
| Total digestible nutrients | 38.8 |

* Bressani and Navarrete (15)

The caulote has been tested in rabbit diets, showing a total digestible nutrient content of around 39%, value which is slightly below that of a high-quality forage. It has also been tested as component of poultry diets, but its high crude fiber content is a limiting factor. Studies started some time ago (15) have been reinitiated using young ruminants.

Finally, another tropical fruit which is being increasingly produced in Central America is cashew. The Central American Bank for Economic Integration has promoted the cultivation of this crop for the purpose of exporting the economically-attractive cashew nuts (16). Some work has also been done on the use of the juice of the cashew apple for wine and vinegar production, but availability of the apple is increasing and interest to use it as an animal feed has developed. Its chemical composition is shown in Table 13. The amount of water is relatively high; however, when processed for juice production, moisture levels drop and the bagasse can be dehydrated or ensilaged. Studies concerning this process are under way in our laboratory.

**TABLE 13**

**PERCENTAGE CHEMICAL COMPOSITION OF CASHEW APPLE**
*(Anacardium occidentale)*

| | |
|---|---|
| Moisture | 87.1 |
| Protein | 0.8 |
| Ether extract | 0.2 |
| Crude fiber | 1.5 |
| Ash | 0.3 |
| Carbohydrate | 11.6 |

The present paper proves that tropical areas of the world, in this case limited to Central America, have a variety of fruits which could play a useful role as components of high-quality protein foods for human feeding, or as animal feed ingredients, replacing partially or totally the cereal grains such diets now contain. Although we have not made any mention of the economic aspect in using them for the above purposes, we feel that attention should be given to them since at the present time more than 80% of the total production or of its availability is lost. Furthermore, the rational utilization of these fruits would increase the efficiency of land utilization and of the natural resources of these countries.

## RESUMEN

### Composición y posible uso, en la nutrición, de algunas frutas tropicales

Se describe el papel nutricional que las frutas podrían desempeñar en dietas de baja calidad, utilizándose como fuentes de vitamina A y ácido ascórbico. Se presenta también información sumarizada sobre algunas frutas tropicales desconocidas de sabores muy variados, que existen en cantidades relativamente abundantes en Centro América y que podrían usarse como componentes de alimentos ricos en proteína, ya que aportan nutrientes tales como provitamina A y ácido ascórbico. En los estudios realizados a este respecto se agregó en forma de puré pulpa de fruta fresca o secada por tambores, a una mezcla de maíz y frijol de soya. En todos los casos se constató un descenso en la calidad de la proteína, el cual fue más marcado en algunas frutas, probablemente debido al proceso de deshidratación usado. Por otra parte, se proporcionan datos sobre la composición química de otras frutas tropicales cuyo consumo no se acostumbra, pero que podrían aprovecharse en alimentación animal. Este tipo de frutas incluye el Chalum (Inga Spp) y algunas cucurbitáceas. Otras tienen semillas con un alto contenido de aceite y proteína. Entre estas últimas, la jícara (Crescentia alata) ofrece buenas posibilidades industriales.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